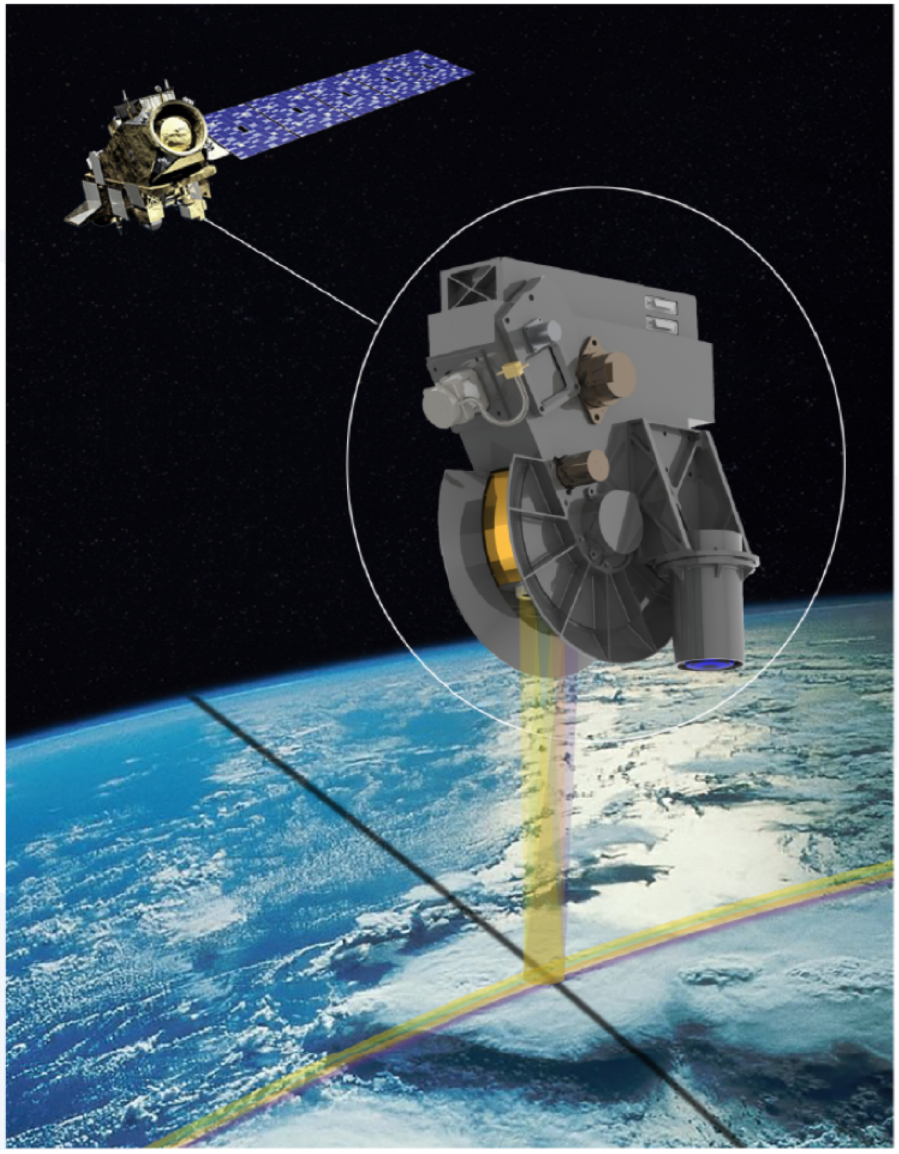

Libera
Understanding Earth's Energy Budget
LASP • JPL • LBL • UA • CSU • UM • NIST • NOAA • Ball • SDL

Libera, EVC-1 Mission

Li'be-ra, named for the daughter of Ceres in ancient Roman mythology



Provides continuity of the Clouds and the Earth's Radiant Energy System (CERES) Earth radiation budget (ERB)

- Measures integrated shortwave (0.3–5 µm), longwave (5–50 µm), total (0.3–>100 µm) and ***(new) split-shortwave (0.7–5 µm)*** radiance over 24 km nadir footprint
- Includes a ***wide FOV camera*** for scene ID and simple ADM generation to pave way for future free-flyer ERB observing system

Innovative technology:

- ***Electrical Substitution Radiometers using VACNT detectors***

Primary operational modes:

- Cross-track and azimuthal scanning; on-board calibrators; solar and lunar viewing.

Flight:

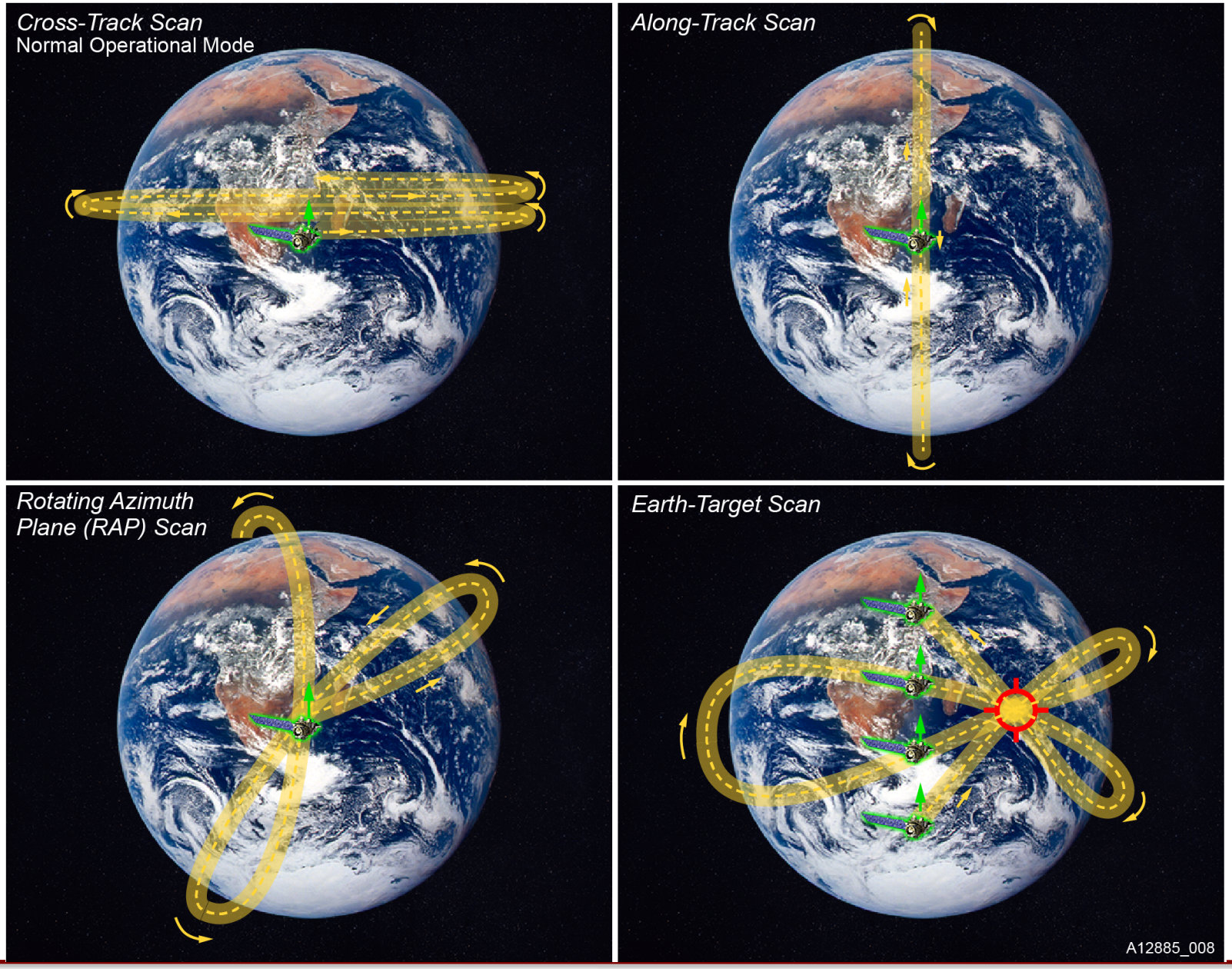
- JPSS-3, 2027 launch; 5-year mission

Partners:

- LASP, Ball Aerospace, NIST Boulder, Space Dynamics Lab; CU, JPL, CSU, UA, UM, LBL

PI: Peter Pilewskie, CU LASP; DPI: Maria Hakuba, JPL
PM: Brian Boyle, CU LASP
Instrument Scientist: Dave Harber, CU LASP

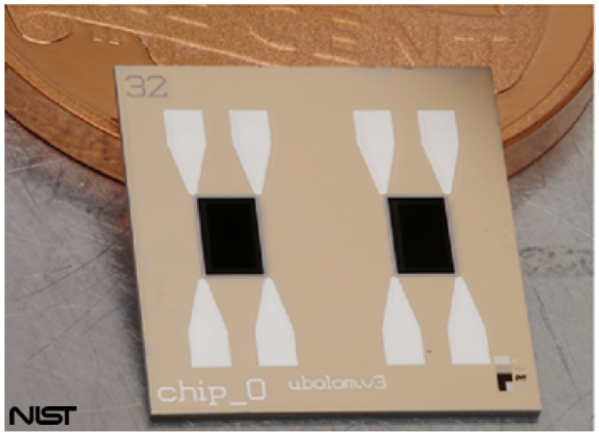
Libera Operational Modes



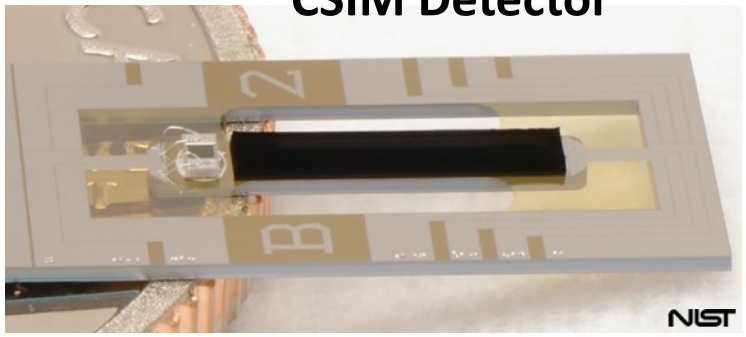
Article in *New York Times*, Nov. 11, 2019

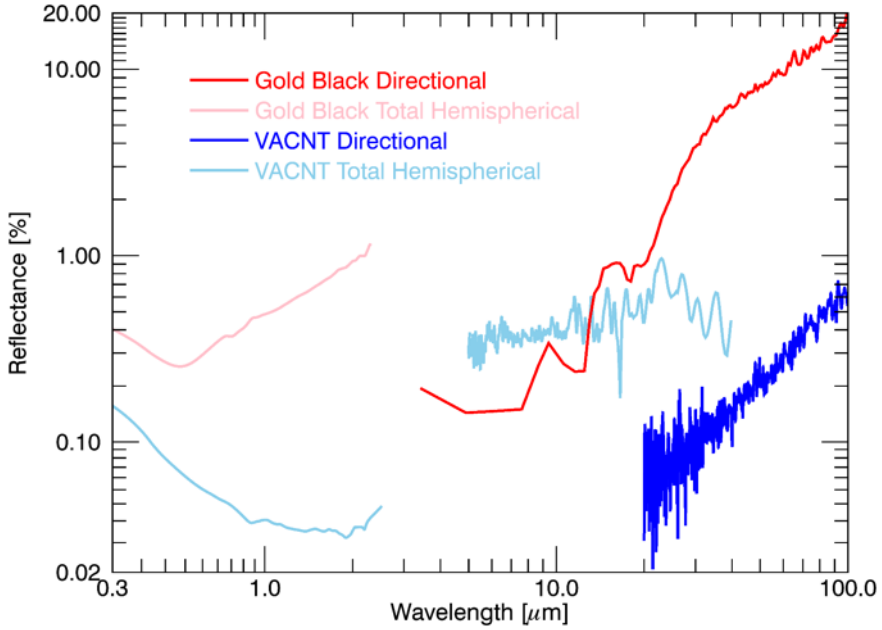
Libera Detector Coating

- The *Libera* detectors use a carbon nanotube (CNT) optical absorber
- CNT coatings have demonstrated the lowest reflectance from the UV through the far IR of any material
- On-orbit performance of CNT absorber has been demonstrated on the CSIM CubeSat

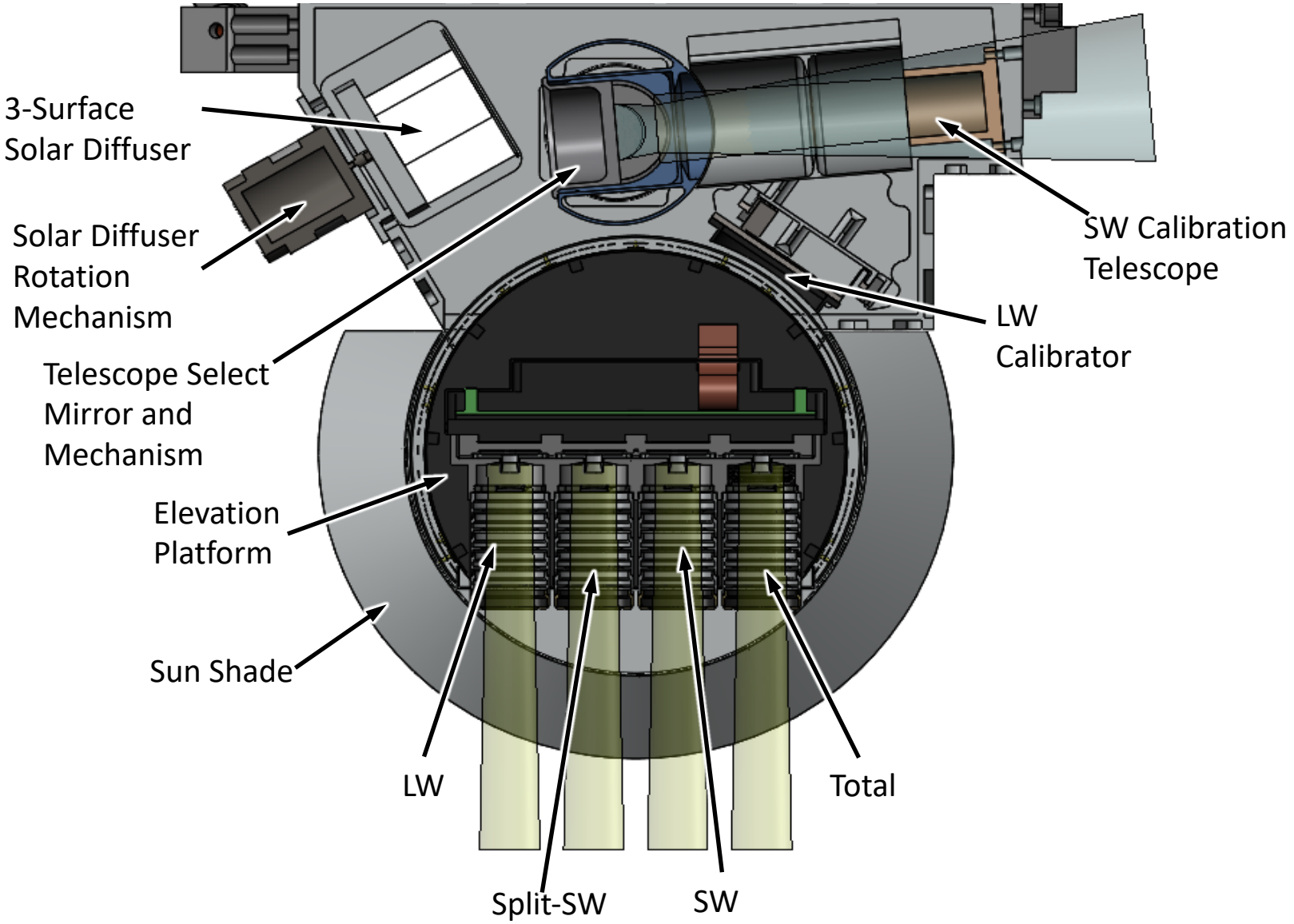


CSIM Detector



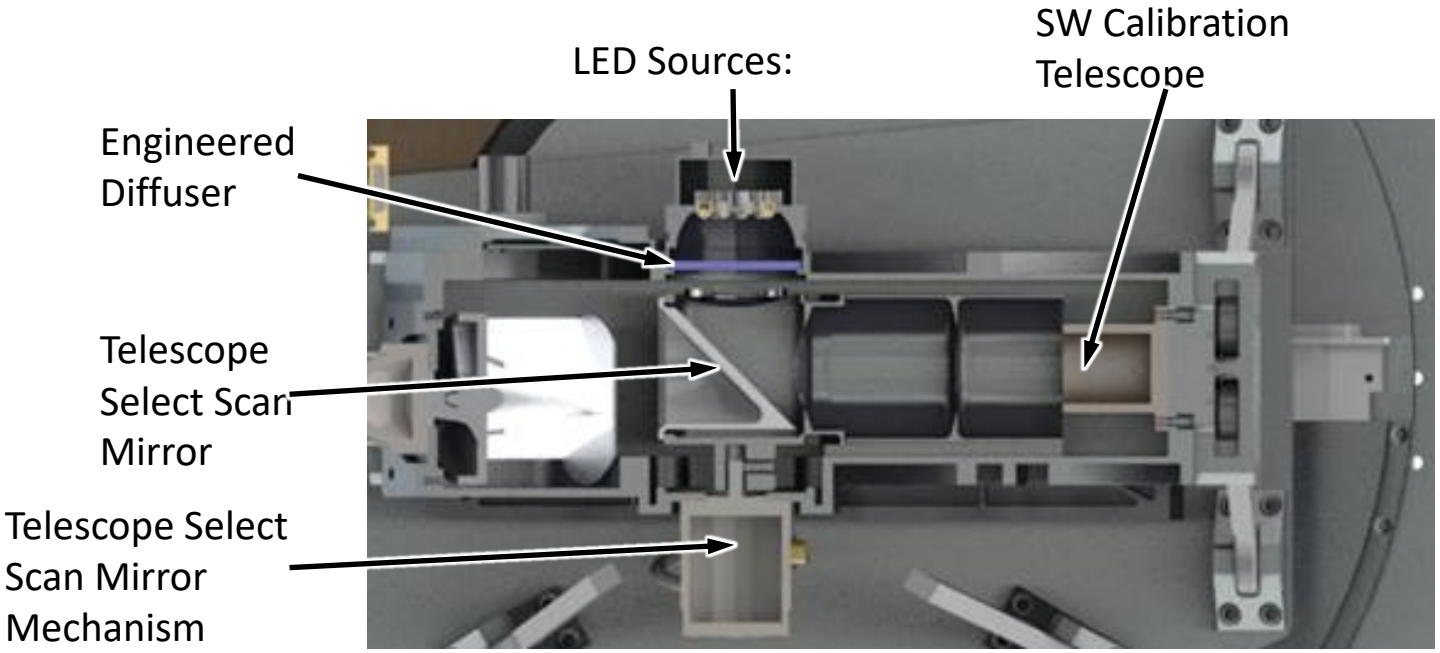


Libera Instrument Details



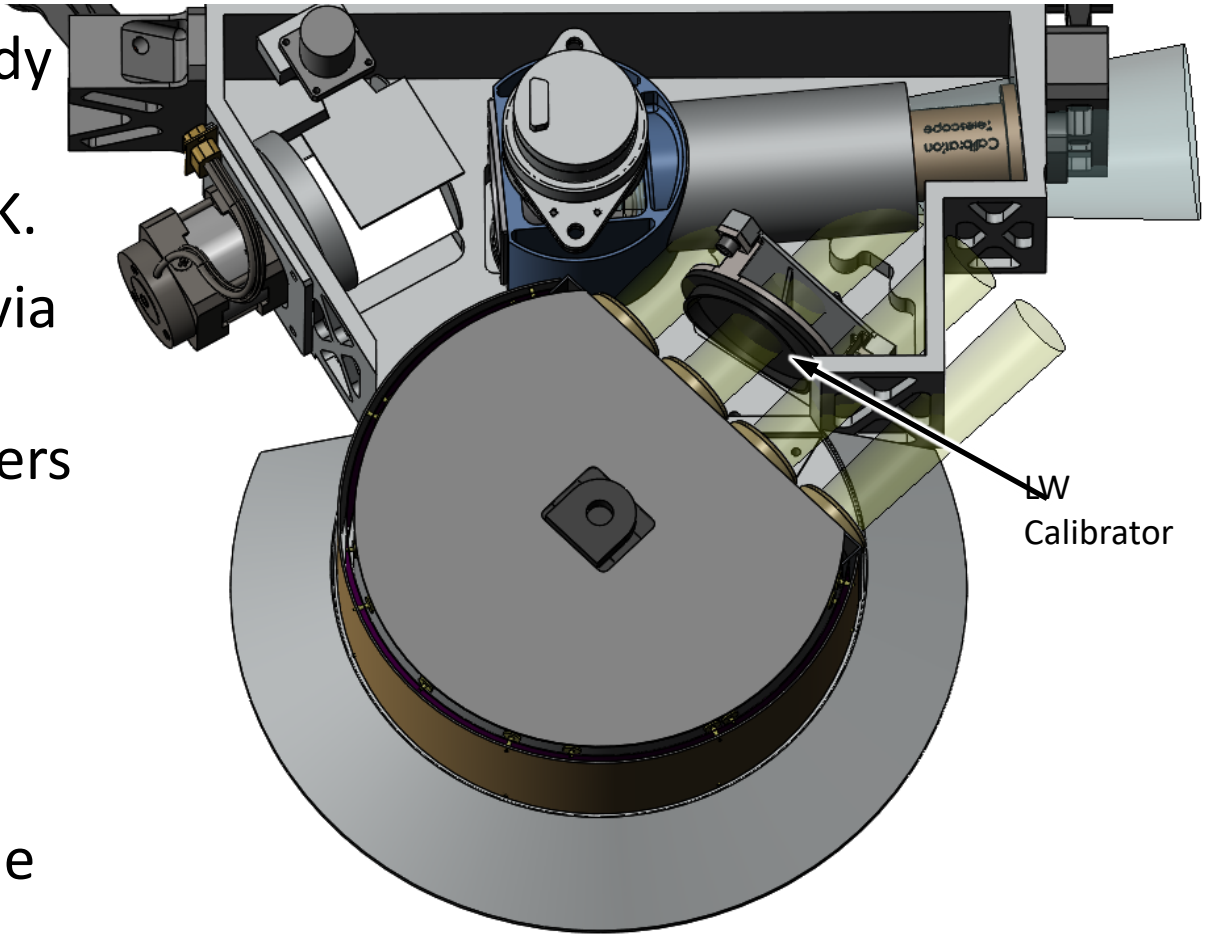
SW Internal Calibrator Cross-Section

- Degradation of the SW, Split-SW, and Total channels in the SW will be monitored at 6 wavelengths with respect to a reference SW calibration telescope: 375, 405, 469, 660, 810, 1550 nm
- SW calibration telescope is used for calibration tracking so it *views only the internal LED sources*



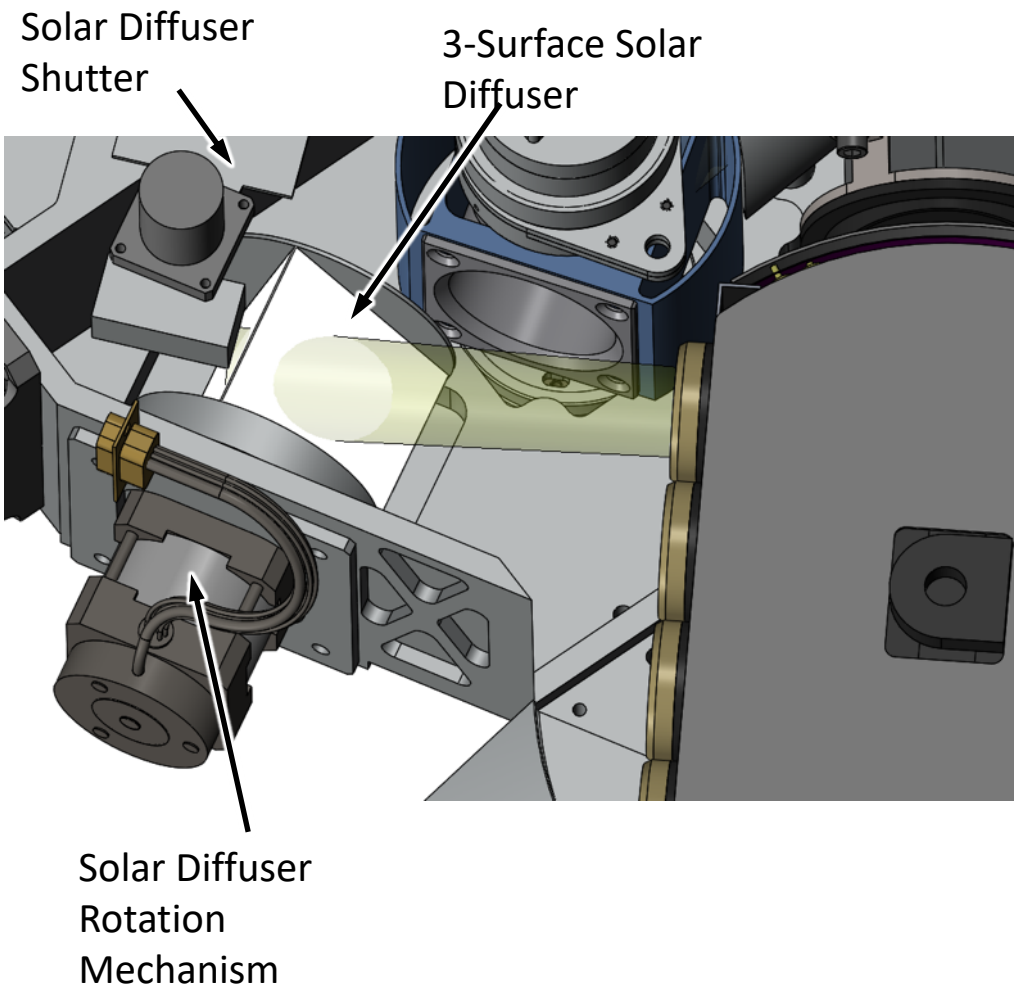
LW Internal Calibration

- CNT flat plate blackbody with high emissivity, tunable from 300-350K.
- Radiance is traceable via calibrated platinum resistance thermometers and SI traceable measurements of the surface emissivity
- Current on-orbit demonstration with the CIRiS CubeSat



Solar Diffuser

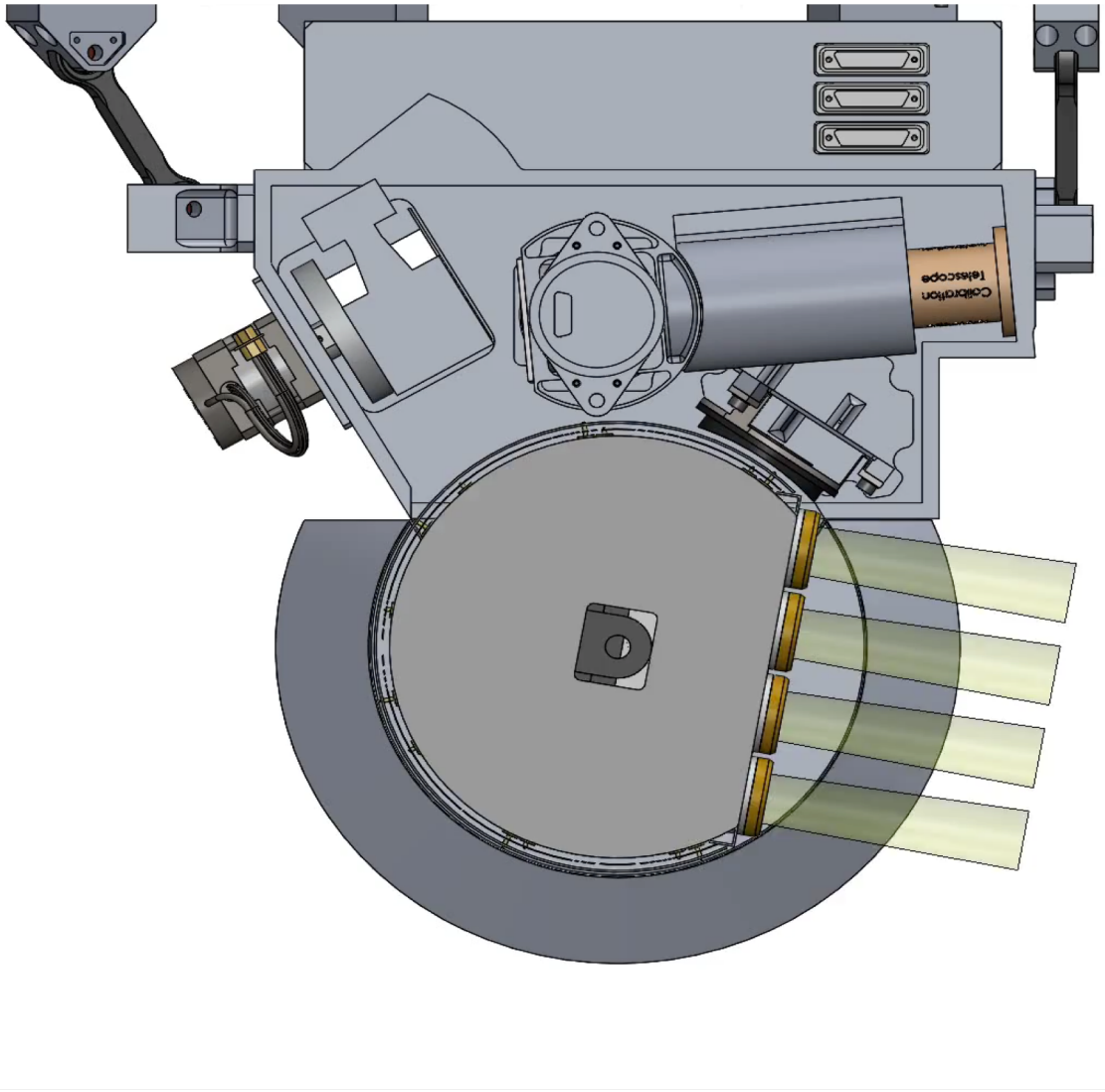
- Three-surface solar diffuser using *Spectralon*:
  - Primary observed weekly
  - Secondary observed monthly
  - Tertiary observed semi-annually
- By comparing the observations from each surface we can detect and correct degradation on the primary and secondary diffusers.
- Solar diffuser is protected by a shutter that opens only for solar calibrations.



Libera Mechanism Animation

Steps of Animation

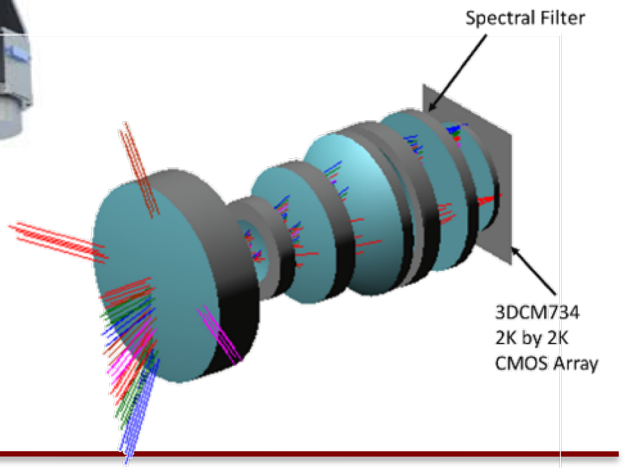
1. Limb-to-limb elevation scan
2. LW calibrator views
3. SW calibrator views
   - Note the telescope select mirror mechanism motion
4. Solar diffuser views
   - Note the solar diffuser shutter opens only for the solar calibration



WFOV Camera

- Wide Field of View Camera
  - 140˚ FOV
  - 1 km sampling at NADIR
  - Bandpass: 865 nm, 10 nm bandwidth
  - 2K x 2K CMOS focal plane array
- Demonstrates the feasibility of a smaller, simpler imager for scene identification and development of angular distribution models

WFOV Optical System



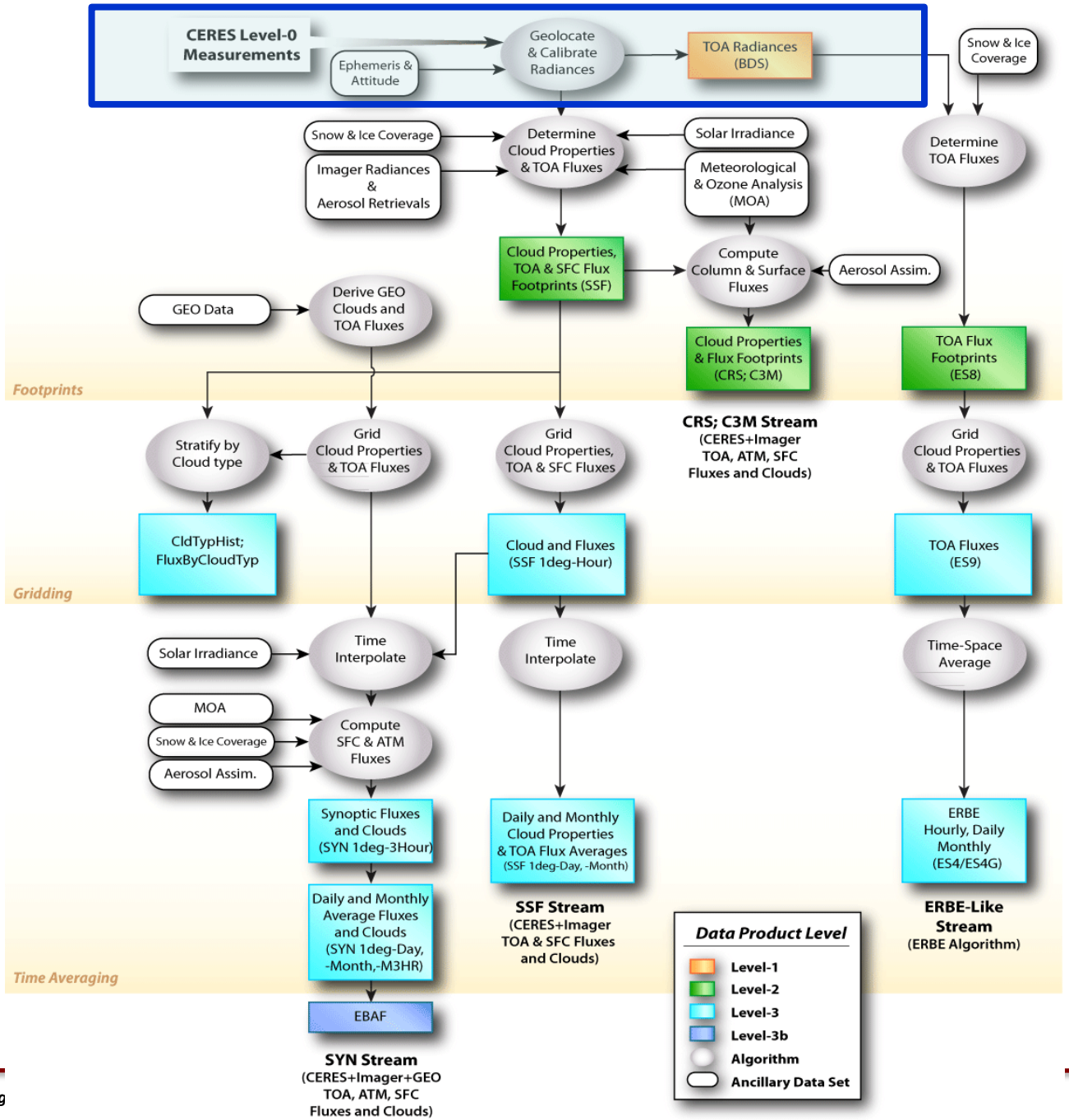
Characterization & Calibration

- Component-Level
  - Optical properties of mirrors, filters, and detectors will be characterized across the full spectral range
- Integrated System
  - The integrated telescopes (mirrors, filters and detectors) will be calibrated directly against a SI-traceable irradiance detector
  - Will be performed at a series of laser tie points from 0.3 µm – 184 µm
  - Will be repeated with an ambient blackbody and a quartz tungsten halogen lamp
  - A subset of these calibrations will be repeated following instrument integration
  - At this point the *Libera* instruments will have a SI-traceable calibration
- Following environmental testing *Libera* will be transported to SDL for an independent validation of the Libera calibration

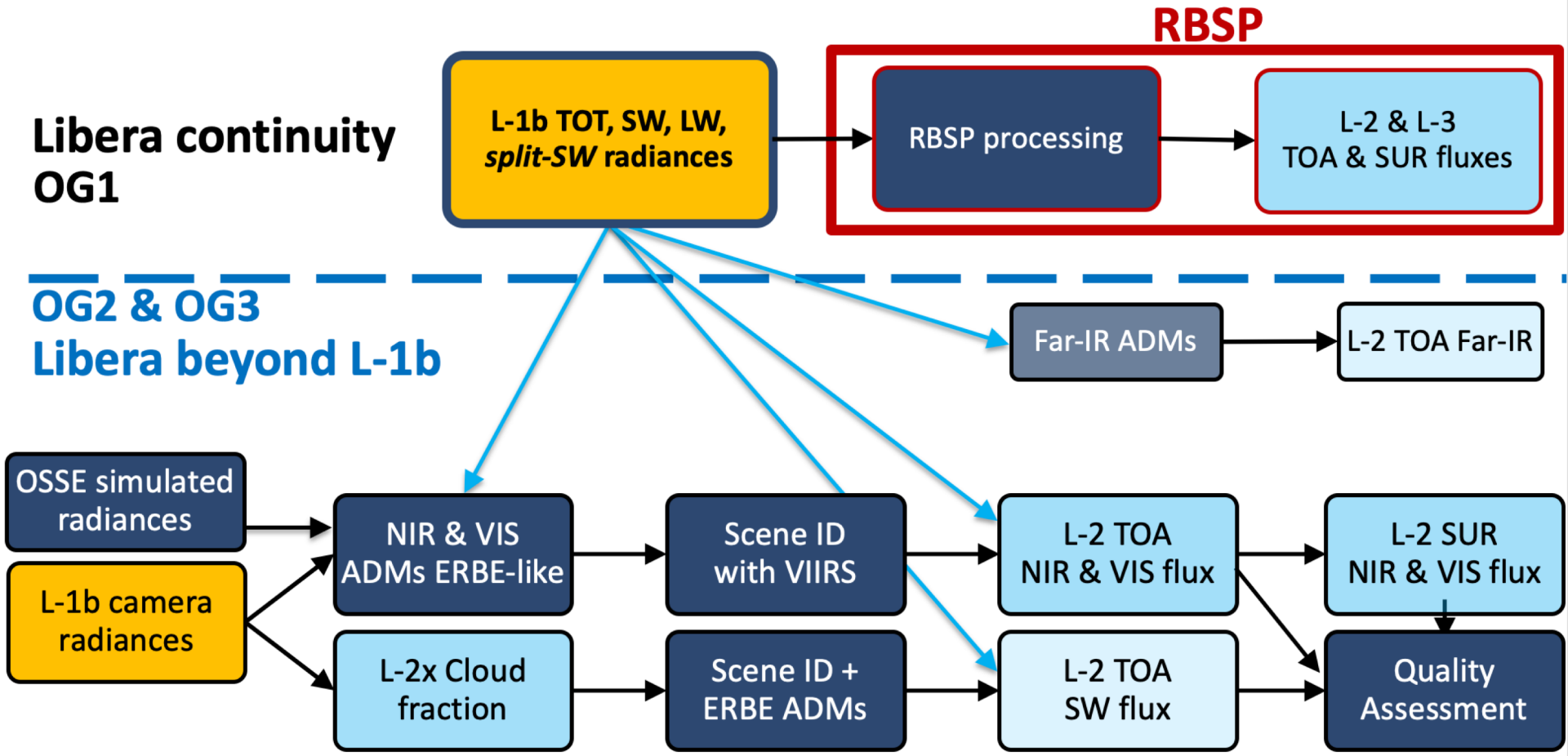
Libera Instrument Summary

- The *Libera* instrument shares many key design details with CERES to preserve data continuity
- *Libera* detectors and the internal calibration system will reduce uncertainties in the future ERB data record
  - Introduces new technology and lays the groundwork for future ERB instruments
- Libera adds a split-SW channel to derive SW VIS and NIR fluxes that add information on shortwave energy deposition.
- Includes a wide field of view camera for scene ID and simple ADM generation to demonstrate future free-flyer ERB observing system
- Extensive component and system level calibration plan supplemented by an independent validation of the instrument calibration

CERES Data Processing Flow



Libera Science Data Flow



Libera Science & Data Plan

Products & tasks	Specifics	Responsible	Team lead
L-1b radiances	TOT, LW, SW to RBSP	LASP	Peter Pilewskie
L-1b camera radiances	865 nm (15 nm), WFOV	LASP	Sebastian Schmidt
OSSE simulated radiances	Multi-spectral, multi-angle	LBL	Daniel Feldman
ADMs NIR & VIS	ERBE-like	NOAA/CIRES	Jake Gristey
Cloud fraction & Scene ID	L-2x, 1km, instantaneous ERBE-like	LASP	Sebastian Schmidt
TOA fluxes NIR & VIS	L-2x, SSF, ERBE-like	LASP/JPL	Maria Hakuba
SUR fluxes NIR & VIS	L-2 & L-3, SSF	UA	Xiquan Dong
Far-IR fluxes	TOT-(SW+LW), L-2 TOA	UM	Xianglei Huang
Quality assessments	NIR & VIS fluxes; TOA & SUR	JPL	Maria Hakuba
SO1 & SO3 Science	Beyond data production	All	All

Summary

Libera will:

- Measure broadband scattered SW and emitted LW radiances at climate quality levels of accuracy, precision, and stability.
- Maintain continuity and extend the ERB climate record
- Produce the daily global set of Level 1b radiances for the RBSP
- Demonstrate a pathway toward a sustainable, reproducible, and innovative observational approach that:
  - Enhances scientific merit
  - Reduces cost and the risk of gaps in future ERB measurements
  - Enables technology infusion to enhance capabilities of a future climate observing system
  - Advances our understanding of the Earth climate system with novel research and analyses.